17 Climate and Natural Disasters

17.1 Introduction

17.1.1 Background and scope

This chapter will address the impacts and associated risks of climate and projections of future climate change on the project. Specifically, this section discusses local climate characteristics, seasonal conditions (for consideration particularly during the construction phase), extreme climatic events and climate change as it relates to the project. The chapter includes an assessment of potential impacts and measures to mitigate those impacts throughout the design, construction, operation and decommissioning phases of the railway project.

A comparison of recent environmental observations with historically longer term indicators suggests that there has been a significant change in climate over the last century. Since the 1950s, Australian temperatures, on average, have risen by about 0.9°C, with an increase in the number of maximum temperature days and a decline in the number of frost days. Rainfall patterns have also changed - the northwest has seen an increase in rainfall over the last 50 years while much of eastern Australia and the far southwest have experienced a decline. These observations fall outside the normal patterns historically displayed in El Niño and La Niña events. Recent observations suggest that there has been an increase in the frequency of hot nights and a decrease in the number of cold nights. The Australian Bureau of Meteorology (2008) reported that Australia's annual mean temperature for 2007 was the sixth warmest on record (0.67 °C above average), with both the maxima and minima above the 1961–1990 average. Australia has now recorded a warmer-than-average year for 16 of the past 18 years (former Environment Protection Agency 2008).

The understanding of climate change has accelerated to the point where it is now agreed that most of the observed abnormal changes in our climate can be attributable to increased concentrations of Greenhouse gases (GHG), from anthropogenic (human derived) activities such as the burning of fossil fuel or land clearing. These changes in the observed climate are not globally uniform but vary from region to region. Thus the impacts from climate change vary depending upon the location studied.

The Greenhouse effect is a natural process and describes the roles of water vapour, carbon dioxide and other trace gases in keeping the Earth's surface warm. However, human activity is contributing to increased amounts of heat by increasing the amount of trapped gases in the atmosphere. These increased concentrations of gases are accelerating the natural Greenhouse effect and resulting in the climate changes we are now experiencing.

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (2007) identified the SEQ region as one of the six 'hotspots' in Australia highly vulnerable to the impacts of climate change. The report advises that 'SEQ's ongoing development is likely to be exasperated by large losses to the built environment from rising sea level, storm surges and flooding' (IPCC 2007).

According to the Climate Change in Queensland Report (2008), climate change is expected to have a number of impacts in South East Queensland (SEQ), such as:

- a marked drying trend since 1950
- the potential for more significant increases in inundation as a result of storm surges due to higher mean sea level and more intense weather systems
- an increase in 1-in100 year storm tide events projected to be 0.45m along the Sunshine Coast, mostly due to sea level rise
- less water available in the future for cities, industries, agriculture and natural ecosystems
- the number of days over 35°C are expected to increase in the future, potentially affecting peak energy demand
- an increased pest and disease risk.

The vulnerability of the project to other hazards such as bushfires and earthquakes is assessed in **Chapter 19, Hazard and risk**. The contribution to Greenhouse gas emissions this project may have is discussed in **Chapter 16, Air environment**.

17.1.2 Aims

This chapter aims to identify and examine:

- existing local climate events including magnitude and seasonal variability and any specific factors that may affect management of the project
- historic weather patterns in the project area
- seasonal conditions that may influence construction
- methods to manage any seasonal conditions
- major extremes of climate on the project
- possible water management options at the project
- the implications of climate change on the project.

This chapter does not include a description and assessment of the natural hazards relevant to the project area as defined in State Planning Policy 1/03 Mitigating the Adverse Effects of Flood, Bushfire and Landslide as these are described in Chapter 19, Hazard and risk.

17.1.3 Relevant legislation and policy

The following policies and legislation relating to the effects of climate on infrastructure and construction projects have been identified as relevant to this project.

Queensland legislation and policies

Climate Change Impact Statements (CCIS) (2008)

The CCIS became a standard inclusion in all submissions to Cabinet from 1 July 2008. Projects that will contribute to GHG emissions and be affected by the impact of climate change must include a statement of GHG emissions emitted and mitigation and adaptation measures undertaken. The level of detail required for a CCIS will be phased in to allow agencies time to understand the scope of reporting. A CCIS has been prepared for the project, details of which are discussed in **Chapter 16, Air quality**.

Climate Smart 2050 (2007)

- reinforces Queensland's commitment to contribute to national targets to reduce GHG emissions by 60% from 2000 levels by 2050
- establishes long term goals to meet the national GHG emissions reduction target and provides a platform to work towards a low carbon future
- provides $414 million investment to deliver the next steps in Queensland's climate change response.

Climate Smart Adaptation 2007-2012 (2007)

- provides an action plan for managing the impacts of climate change
- builds on results from the public discussion paper of 2005 'What does climate change mean for you?'
- presents a case for early action as a cost effective focus to 'enhance Queensland's resilience to the impacts of climate change'
- targets sectors by prioritising their vulnerability and ability to adapt to the impacts of climate change.

Integrated Planning Act 1997 (IPA)

- establishes the State's principle planning mechanism to achieve ecological sustainability
- influenced by community values related to the natural environment, economic and social issues.

Regional policies

South East Queensland Regional Plan 2005-2026

- applies a regional context to policies aiming to achieve sustainable development in SEQ communities
- ensures that the region grows and changes in a sustainable way
- establishes a range of 'state of the region sustainability indicators' for periodic monitoring and reporting at regular intervals
- outlines regional policies designed to guide local government planning processes and decision-making.

The SEQ Regional Plan 2005 – 2026 refers to climate change adaptation in Policy 2.3.2 and requires local government to assess the impact of potential climate change in preparing planning schemes and land use strategies.

Caloundra City Corporate Plan 2006-2011[1]

The Caloundra Corporate Plan 2006-2011 has seen the incorporation of climate change issues and opportunities in the policy framework. In the Corporate Plan, climate change is noted as one of the primary environmental issues affecting Caloundra City and is discussed in the section on Assessment of Local and Regional Issues.

Caloundra City Council Cities for Climate Protection Milestone 5 Report 2007

The Milestone 5 Report provides an update on the progress towards reduction goals and reassesses the strategic direction of the 2005 Greenhouse Action Plan. The report included a revision of the GHG Emissions inventory undertaken in 2000 and quantification of GHG reduction activities identified in the 2005 Greenhouse Action strategy.

Maroochy Shire Council Corporate Plan 2005-2007[2]

- identifies climate change and development of adaptation strategies to address projected changes in climate as a priority issue.

Maroochy Shire Council Energy Management Strategy January 2007[3]

- details actions for council's involvement in the Cities for Climate Protection Program and its commitment to reducing Greenhouse gas emissions both within the community and its own operations.

Caloundra City Plan 2004

There are a number of codes within council's Planning Scheme, the *Caloundra City Plan 2004*, that assist in the planning process to ensure that development addresses risks arising from natural disasters and hazards including those associated with climate change.

1 *Since drafted, these plans are now under purview of the March 2008 amalgamated Sunshine Coast Regional Council*

2 *Refer to Footnote 1*

3 *Refer to Footnote 1*

Climate and Energy Code

The Climate and Energy Code promotes resource efficient building design in both residential and non-residential development. For instance, it is important that buildings are sited and designed to take advantage of natural climatic conditions and environmental opportunities such as sun and shade. The code also aims to ensure buildings are sited, orientated and designed to achieve a high level of thermal comfort for living and working environments and resulting in a reduction in reliance on lighting devices, energy reliant heating, cooling and ventilation.

Disaster management

The council has a Local Disaster Management Group and Local Disaster Management Plan in place to manage events such as severe storms. The plan is exercised from time to time to ensure that adequate capacity is available if such an event arises.

17.2 Methodology

17.2.1 Review of existing information

Information review (from existing reports)

A number of reports were assessed for relevance and used for general background information, including:

- *South East Queensland Infrastructure Plan and Program* 2007 – 2026
- *Rail Network Strategy for Queensland* 2001 - 2011
- Caboolture to Beerburrum Community Infrastructure Designation, Final Assessment Report (2006), QR Limited
- Landsborough to Nambour Rail Corridor Study: Route Identification Report (former Queensland Transport now Department of Transport and Main Roads, 2008)
- *Climate Change in Queensland – what the science is telling us* (Queensland Office of Climate Change, June 2008).

Spatial and climate data

Historical meteorological data from the Queensland Department of Employment, Economic Development and Innovation Nambour station has been used to create a picture of the current and possible future climate of the project area.

This report has used SimCLIM (climate change simulation model) to create regionally specific future scenarios of climate change. SimCLIM is a computer model system for examining the effects of climate variability and change over time and space. Its 'open-framework' feature allows users to customise the model for their own geographical area and spatial resolution and to attach impact models. The model uses a digital elevation model (DEM) to present the climate scenarios as a spatial mapping output. SimCLIM uses the climate trends and projections data published by the Queensland Office of Climate Change (June 2008), sourced from the Bureau of Meteorology and CSIRO. SimCLIM also incorporates the following climate projection variables within its modelling program:

- General Circulation Model (GCM)
- Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES)
- Climate Sensitivity Levels.

SimCLIM (CLIMsystems Ltd) software product was developed by the International Global Change Institute (IGCI) at the University of Waikato in New Zealand and Arup has acquired a commercial licence to use the model. The basic code used by the CSIRO Division of Atmospheric Research for their OZCLIM is an earlier version of the SimCLIM model and also provided by the IGCI.

For the purpose of this report the geographical boundings for the Sunshine Coast Regional Council (as defined by the Sunshine Coast State Electoral Map) have been used to incorporate the project area.

Sunshine Coast Regional Council Geographic Bounding Box:

- North Bounding Latitude: -25.80389
- South Bounding Latitude: -27.15417
- East Bounding Longitude: 153.2072
- West Bounding Longitude: 152.3675.

Public databases

The historically observed climate data used in this chapter to create the baseline climate was accessed from the Bureau of Meteorology website. The DEM and projected climate data used in the SimCLIM model was provided by the IGCI and this was obtained through the Bureau of Meteorology (BOM), CSIRO and other governmental and institutional sources.

Better resolution data is potentially available from other sources including volunteer precipitation recording (Department of Employment, Economic Development and Innovation) and Local Government. Data standardisation and quality control of such sources will be refined as this science improves.

A thorough understanding of the quality of sources and accessibility of data is an essential ingredient for assessing the risks and vulnerability of projects to climatic induced changes. The quality of modelling output is determined by the availability and quality of data.

17.2.2 Limitations of study

Baseline local climate, extreme and historic events data are based on the most up to date information available for the project area based on desktop analysis. In the absence of any available climate change modelling for the project area, future projections of climate change at a local scale within the project area are unavailable. As a result, the most informative projections of future climate change are at a regional scale, as specified in the geographical bounding in **Section 17.2.1**.

Other limitations of this report include:

- Only one meteorological station was identified as relevant for use in the analysis of historical weather patterns, located at the Nambour Department of Employment, Economic Development and Innovation site (former DPI). This could produce data biases.
- Only regional level climate change modelling was able to be simulated due to the quality and resolution of climate and spatial data used in SimCLIM (25m DEM and one meteorological station within the project area).
- To generate scenarios of future temperature and precipitation in SimCLIM, the CSIRO GCM pattern and the A1FI (fossil fuel intensive SRES) were used. The A1FI SRES scenario is generally agreed to be 'worst case' scenario.
- 2030 was used as the future year to be consistent with the projections in the Office of Climate Change reporting (Office of Climate Change 2008).

17.2.3 Assessment of impacts

The impact of the project has been described, and mitigation or management measures are defined. Where there is a residual impact (i.e. an impact remains after the mitigation or management strategies have been applied) the significance of the impact is assigned, in accordance with the approach outlined in **Table 17.2.3**.

Table 17.2.3: Significance criteria for impacts

Significance	Criteria
High Adverse	Impact a major problem. The impacts of local climate, extreme climate events and climate change are likely to be important considerations adversely affecting the project area due to the possible destruction of project infrastructure, severe environmental damage and/or death of project personnel and users as well. These impacts are of concern to the project, depending upon the relative importance attached to the issue during the decision- making process. Mitigation measures and detailed design work will not remove the impacts upon the affected project infrastructure. Residual impacts would predominate.
Moderate Adverse	Impact moderate. The impacts of local climate and /or extreme climate events and climate change on the project area are likely to result in damage to infrastructure, construction delays, environmental damage and/or possible injury to personnel. These impacts represent issues where adverse outcomes would be experienced, but mitigation measures and detailed design work can ameliorate some of the consequences upon affected infrastructure. Some residual impacts would still arise. The cumulative impacts of such issues may lead to an increase in the overall impacts upon a particular area or on a particular resource and hence may become key decision-making issues.
Low Adverse	Impact recognisable but acceptable. Local climate conditions or extreme climate events or climate change can cause localised impacts to the project including delays to construction, increased erosion or minor heath impacts to project personnel. These impacts are likely to be important only on a local scale and are unlikely to be of significant importance in the decision-making process. These impacts are generally of relevance for enhancing the subsequent design of the project and in the consideration of mitigation or compensation measures.
Negligible	Minimal Change: No impacts or those which are beneath levels of perception within normal bounds or variation or within the margin of forecasting error. For example climatic conditions or extreme events do not cause any impacts to the project infrastructure, personnel or surrounding environment.

17.3 Description of environmental conditions

17.3.1 Existing local climate

The project area is located within the coastal lowlands of SEQ and is classified as having a subtropical climate with no dry season. Mean annual rainfall is around 1578mm with the majority received in the summer months (December-April). Mean daily temperatures range between 25-27 °C in summer and 10-14 °C in winter. Surface winds generally reflect the diurnal pattern of land and sea breezes. The prevailing winds tend to be south-easterly during summer and south-westerly during winter. Onshore winds are dominant in the afternoon (ranging from north-easterlies to south-easterlies throughout the year), and the winds tend to get stronger later in the day. **Table 17.3.1.** is a review of data from the Nambour Station, which is the closest to the project area. This data has been obtained from the Bureau of Meteorology.

Table 17.3.1: Meteorological Data Nambour (Department of Employment, Economic Development and Innovation) Station

Temperature	Mean annual daily max. temperature: 25.8°C Mean annual daily min. temperature: 14°C
Humidity	Mean annual relative humidity: At 9am: 67% At 3pm: 59%
Rainfall	Mean annual rainfall: 1696.3 mm Highest rainfall is in February, lowest in September. Mean number of clear days per annum: 71.9 Mean number of rainy days (rain ≥ 1mm) per annum: 104.9

The mean-annual values represent the mean of the annual average temperatures and annual precipitation for a given time period. The mean-annual temperature and precipitation would not necessarily be indicative of the weather that could be expected on any given day, or the precipitation that could be expected in any given year. This is because mean-annual values are skewed by the extreme weather events that occur during the given time period.

Projections in temperature change

The Climate Change in Queensland 2008 Report (OCC 2008) issued by the Queensland Office of Climate Change notes a rise in average temperature since 1910 across Queensland and an even faster rate of temperature rise since 1950, with the rate of temperature increase ranging from 0.07 °C/decade in the far north to 0.32°C/decade in the south west of the State. The past seven years have recorded four of the hottest years since 2002. Queensland now experiences more days with temperatures above 35 °C and fewer nights below 5 °C (OCC 2008).

The report projects a future annual warming over Australia by 2050 and 2070 as high as 2.8 °C and 5.0 °C respectively (under a high emissions scenario of the Intergovernmental Panel on Climate Change (IPCC) Special Emissions Report). By 2030, annual average temperatures in Queensland's coastal areas are projected to increase by about 0.9 °C (range of 0.7–1.2 °C) relative to the climate of recent decades (OCC 2008)

Changes in rainfall

Since the early 1950s, there has been an observed decline in rainfall throughout Queensland, particularly coastal areas.

A greater proportion of total rainfall now falls in extreme events, and there are longer periods between rainfall events. The Queensland Climate Change Centre of Excellence (QCCCE 2007) reported that the 2008 SEQ drought was the worst on record for the catchments to the west of Brisbane, including the Wivenhoe, Somerset and North Pine dams.

The previously recorded drought in SEQ has been associated with a high frequency of El Niño events from 2001–2007 (QCCCE 2007).

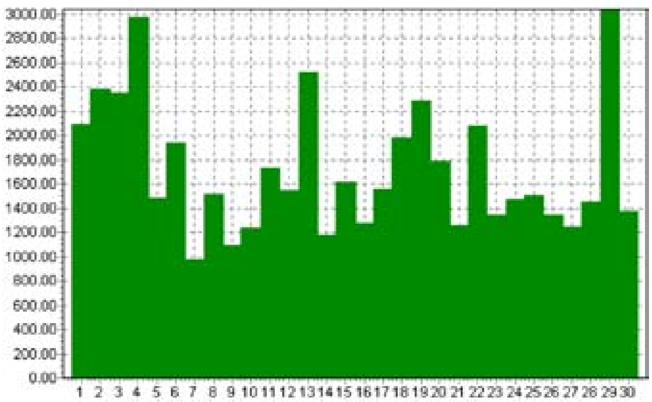
Queensland rainfall is greatly influenced by El Niño events and, as a result, the number of tropical cyclones in the Queensland region has declined since the 1970s, largely due to the increased incidence of El Niño's. However, there has been an increase in the number of severe tropical cyclones (CSIRO et al. 2007).

The Climate Change in Queensland report (2008) notes that current projections for 'winter and spring rainfall is likely to decrease in Queensland in central and southern areas, but changes in summer and autumn rainfall are less certain. Extreme daily rainfall is expected to be less affected by the projected drying tendency and may increase, particularly in summer and autumn'.

In the project area and surrounds, the wettest months of the year are January, February and March and the driest months of the year are June, August and September. This is what would be expected for the subtropical climate that is being examined.

The **Figure 17.3a** shows how the average annual precipitation has varied from year to year for the period 1971-2000 in the project area.

Figure 17.3a: Average Annual Precipitation (mm) 1971-2000 Nambour Station



In summary, the observed average annual precipitation data between years 1971 and 2000 at Nambour Station ranges from approx 1000-3000 mm.

There appears to be a drying trend overall apart from extreme events (e.g. Nambour received over 3000mm in 1999). During the period 1971-1977, the observed data shows a wetter period than in the subsequent two decades. This indicates a trend over this time period of a reduction of precipitation. From observations of the data in SimCLIM, this also coincides with a trend in warmer temperatures. This may result in higher evaporation rates and, consequently, a decrease in water supply.

There is greater uncertainty with rainfall projections, as this depends on the greater atmospheric-ocean circulations and doesn't have a direct relationship to GHG concentrations, as temperature does. As a consequence different GCM patterns produce different outputs of wetting and drying trends. **Modelling** shows the change in precipitation in the wettest months between the baseline year and 2030 for the project area as negligible. However it is informally agreed that the intensity and frequency of rainfall events is likely to change.

Humidity

Evapotranspiration is the combination of evaporation from soil and water surfaces, and transpiration from vegetation. Annual potential evapotranspiration is projected to increase over Queensland. Irrespective of changes in rainfall, increased evapotranspiration will result in an increase in aridity and the severity of droughts.

The following **Figures 17.3b** and **17.3c**, are a comparison of the mean relative humidity observed between 1954-2007 and the mean relative humidity for the year 2007. The Nambour station makes observation at 9 am and 3 pm.

Figure 17.3b: Comparison of Mean 9am Relative Humidity from 1954-2007 and 2007 (Nambour Station Site)

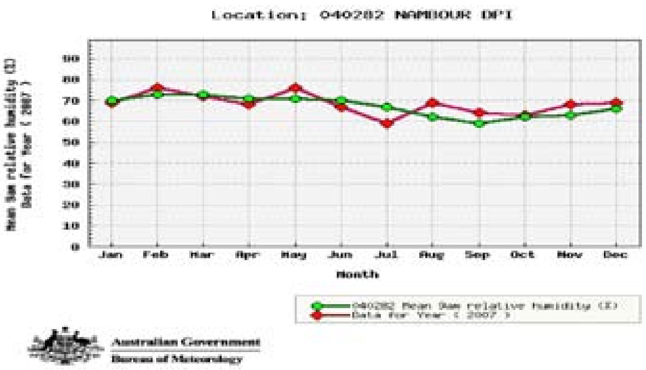
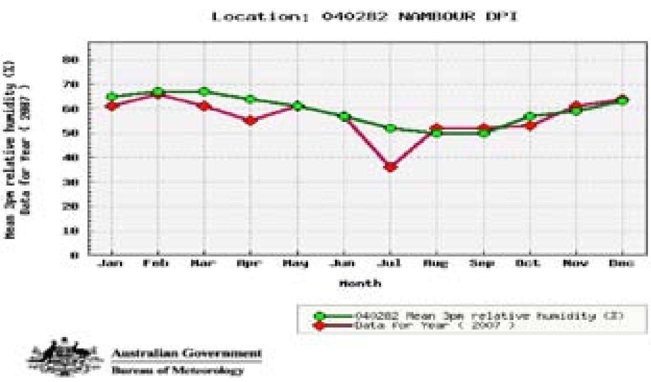


Figure 17.3c: Comparison of Mean 3pm Relative Humidity from 1954 -2007 and 2007 (Nambour Station Site)



Wind

Figures 17.3d and **17.3e** are a comparison of observed mean monthly wind speed (for the period 1954-2007) and observed mean monthly wind speed for 2007. Although 2007 observed data is slightly under the mean monthly, some increase in average wind speed in coastal areas is projected, mainly in winter and spring.

Figure 17.3d: Comparison of Mean 9am Wind Speed from 1954 -2007 and 2007 (Nambour Station Site)

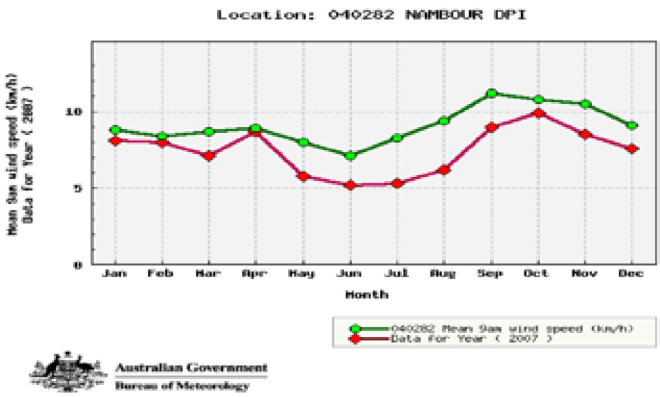
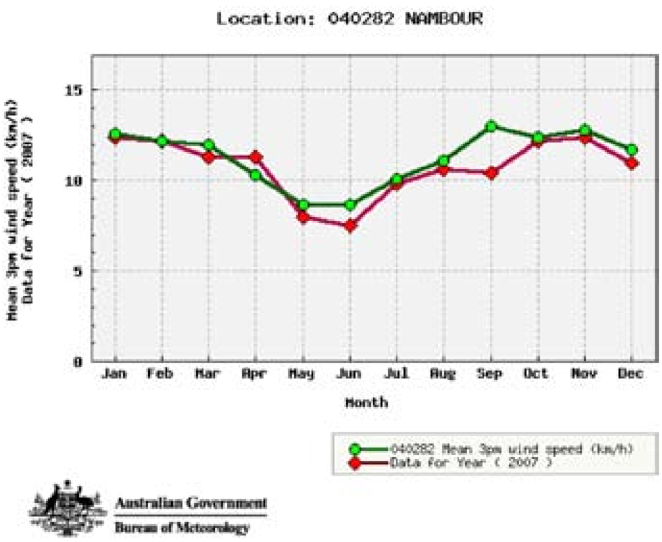


Figure 17.3e: Comparison of Mean 3pm Wind Speed from 1954 -2007 and 2007 (Nambour Station Site)



17.3.2 Extreme climatic events

This section discusses extreme climatic events such as storms, flooding, cyclones and heatwaves that are projected to occur in the project area. An assessment by the IPCC in 2007 noted that SEQ can expect increases in intensity of extreme events by 20-30% in both the mountainous terrain and coastal regions. Therefore, it is likely for extreme climatic events, influenced by season or time of year, to occur in the project area and are considered for the project. These include:

Severe storms

The Sunshine Coast's sub-tropical climate brings with it periods of prolonged and intense rainfall, severe storms, monsoonal (wet season) rains, tropical cyclones and storm surges. All of these factors contribute to the likelihood of flooding. The months between November to February coincide with the summer storm and cyclone season and the increased likelihood of flooding presents significant additional risk. Flooding is discussed in more detail in **Chapter 14, Water resources** and **Chapter 19,** Hazard and risk.

The frequency of hail is projected to increase in SEQ by up to two days per year by 2030 and four days per year by 2070 (Office of Climate Change 2008).

Storm surges are usually associated with tropical storms and cyclones. Storm surges involve rapid seawater flooding resulting from a combination of high tides and heavy seas.

While inundation of seawater alone poses a threat to the coastline and low-lying inland areas, storm surges often coincide with periods of intense and prolonged rainfall. Consequently storm surges threaten to impact on tidal river systems and can increase the severity and extent of inland river and creek flooding during high tide and king tides.

Tropical cyclones

The high wind risk from tropical cyclones can extend as far as 50 km from the coast. The intensity of tropical cyclones is likely to increase as is the frequency of tropical cyclones forming over warmer seas. Tropical cyclones are often concurrent with the global El Nino Southern Oscillation (ENSO) phenomenon. The additional impact of climate change on ENSO will also affect the number of tropical cyclones in the Queensland region (BOM). The Project area and its surrounds are relatively susceptible to tropical cyclones with around eight major cyclones impacting the area since 1954.

Tropical cyclones have been known to cause widespread structural damage on the Sunshine Coast; an example of such is Tropical Cyclone Annie that hit the Sunshine Coast in January 1963 and unroofed homes in Buderim, Landsborough and Maleny. Other impacts include strong winds capable of bringing down power lines, extensive foreshore erosion, storm surges and flooding.

Heatwaves

In the period between 1803 and 1992, a reported 4287 people died in Australia as a direct result of heatwaves. The elderly, especially those living alone, are a particularly susceptible group (AGSO, Bureau of Meteorology 2001).

The number and frequency of extremely hot days is expected to increase from an average of one per year currently experienced in Brisbane to a potential of six days per year (under a high emission scenario) (Office of Climate Change 2008).

17.3.3 Sea level rise

According to the IPCC (2007), sea levels are projected to rise by 59 cm by 2100 due to thermal expansion alone. An additional rise of a further 20 cm is possible from the contribution of ice melts from the polar ice caps and ice sheets.

On a more local scale sea-level rise on the east coast of Australia may be greater than the global mean (Office of Climate Change 2008).

Increases in sea level can also result in increased storm surge risk, particularly along the east coast of Queensland. Consequently, there is also the potential for significant increases in inundation as a result of storm surges due to higher mean sea level and more intense weather systems (Office of Climate Change 2008).

Seal level rise will also contribute to the increase in 1-100 year storm tide events, expected to rise by around 0.45m along the Sunshine Coast (Office of Climate Change 2008).

17.4 Assessment of potential climate change impacts and adaptation measures

The potential impacts of climate change relevant to the project:

- local fluctuations in climate
- extreme weather events
- sea level rise.

For each of the impacts there will be a section detailing the projected impact, mitigation measures and the significance of the residual impact.

17.4.1 Local fluctuations in climate

Potential impact

The potential impacts of local climate and seasonal climate fluctuations on the project include:

Temperature

General circulation models predict an increase in temperatures in SEQ.

- increased risk of bushfires with the number of days of very high and extreme fire danger increasing
- increase in extreme weather events such as floods and drought
- dry conditions leading to increased amount of dust generated from construction activities
- increased wind speeds during a storm are likely to increase the impact of dust generating activities
- high humidity, high temperatures and intense sunshine potentially affecting construction workers, resulting in dehydration, sunburn and/or sunstroke
- potential for the spread of insect-borne diseases (like dengue fever) during warmer, wetter episodes (DNRM 2006).

Rainfall

Although the compounding effects of future climate change on the El Nino and La Nina patterns are producing some conflicting predictions on future drying trends, it is agreed that climate change will increase the intensity of rainfall events.

- increased severity of drought and evaporation from water storages
- increased risk, incidence and severity of bushfires

- heavy rainfall events likely to be more extreme and more frequent possibly leading to riverine flooding and increased erosion of river banks
- erosion likely to increase following a severe storm or flood event
- wet weather potential to hamper construction activities and vehicle access to construction sites
- changes to flood risk and frequency, with potentially higher flood levels and greater risk to infrastructure (Department of Environment and Resource Management 2006).

Mitigation

Mitigation measures are designed to adapt to the effects of Climate Change. This section deals with adaptation as defined in Appendix 3 of the *Guidelines for Preparing a Climate Change Impact Statement* (Office of Climate Change 2008).

Design

The preliminary design has been undertaken to avoid high flood risk areas where possible. Further flood mitigation measures will be incorporated in the detailed design.

Construction

- construction in sensitive areas (close to embankments, flood risk areas and areas of unstable vegetation) that involves earthworks leaving large areas exposed for extended durations be minimised and restricted to months of least rainfall May-November
- control of dust at all times but particularly during windy periods
- the use of erosion and sediment control measures during construction to prevent increased erosion and sedimentation during rainfall events
- monitoring both long and short term weather forecasts during the construction period.

Operation

- earthworks stabilisation measures such as revegetation with appropriate native species.

Residual impact

Change in local climate has the potential to have an influence on the environment in the project area during construction or operation of the project. Mitigation measures that have been proposed are considered adequate to reduce the impact of these conditions or events to negligible or low adverse.

17.4.2 Extreme climate events

Potential impact

Tropical cyclones and severe storms

The intensity of tropical cyclones is expected to increase and consequently thunderstorms and other severe weather events due to expected higher wind speeds. These events can greatly damage both rail and associated infrastructure, including possible electricity shutdown at stations. Hail, landslides and erosion severity can also increase as a result.

Severe storms which bring hail, lighting and high winds are expected to economically impact the project from potential infrastructure construction delays and personnel issues relating to health and safety. The impacts are more likely to be localised than that of a tropical cyclone and more likely to occur in the summer months (Nov-Feb). The effects may include damage from torrential rain, high wind, hail and lightning.

Localised flooding can also occur when parts of the storm water drainage systems (such as pipes, gully traps and minor culverts) are blocked or capacity is exceeded.

A cyclonic event or severe storm has the potential to cause flooding of construction areas.

Rail infrastructure and bridges are generally resilient to flooding. The main impacts of flooding could be:

- flooding of cuttings
- embankment instability
- signalling disruptions
- damage to overhead power supply.

These impacts can be addressed relatively quickly after an extreme weather event and are unlikely to compromise the integrity of the railway.

Temperature

Temperature is projected to increase with the number of days over 35 degrees increasing and as a result increasing the risk associated with the incidence and severity of bushfires. More detail on the risk of bushfire is provided in **Chapter 19, Hazard and risk.**

More frequent heatwaves would have implications on community health and demand on power and with increased rail buckling risk. In addition, heatwaves may affect the rail and increase the risk of derailments. In fact, the majority of track in use is now Continuously Welded Rail (CWR), without any joint in the rail. This does not allow for the rails to expand in hot weather. CWR is installed at the 'neutral temperature', which is the temperature where there is no longitudinal stress in the rail. This is achieved at installation through management of the rail temperature. As the rail temperature rises above the neutral temperature, longitudinal forces can cause the rail to buckle sideways, which, in extreme cases, can result in serious derailments.

Mitigation measures

Mitigation measures are designed to adapt to the effects of Climate Change. This section deals with adaptation as defined in Appendix 3 of the *Guidelines for Preparing a Climate Change Impact Statement (Office of Climate Change 2008).*

Design

The preliminary design has been undertaken to avoid areas subject to inundation (i.e. design level has been set above ARI 100). Flood opening allowances (i.e. culvert and bridge sizing) established during preliminary design are conservative, and will require refinement during detailed design.

Construction

- Health and Safety Management Systems to ensure appropriate procedures are in place to prevent health and safety incidents arising as a result of extreme climatic events

In particular, implementation of health and safety procedures to reduce the risk of dehydration, heat stroke or sunburn that may affect project personnel during construction, particularly during heatwaves.

- modify work hours during heatwaves so as to limit number of hours construction personnel exposed to high temperatures
- monitoring both long and short term weather forecasts during the construction period
- postpone construction work during periods of cyclones, severe storms and other extreme climatic events
- preparation of a disaster management plan and an emergency management plan for the project construction
- earthworks stabilisation measures, such as revegetation with appropriate native species, dust suppression and construction staging so that large areas are not exposed (or left untreated) for extended durations.

Operation

- Health and Safety Management Systems will be followed during operations to ensure appropriate procedures are in place to prevent health and safety incidents arising as a result of extreme climatic events.
- Resistance to buckling will be developed during a consolidation period with train traffic at reduced speed.
- During times of high temperatures, speed restrictions will be observed in accordance with QR Limited Safety and Security Standard SAF/STD/0075/CIV Hot Weather Precautions for Track Stability. QR Limited has advised when the air temperature reaches 38°C, all trains are restricted to 120km/h; when the air temperature reaches 40°C, all trains are restricted to 60km/h. These trigger temperatures can be increased by 3°C when certain conditions related to the stability of the track are met.
- The condition of the tracks will need to be monitored regularly, in particular during heat waves, to prevent any damage to the tracks.
- A disaster management plan and an emergency management plan should be prepared for the project operation.

Decommissioning

Flooding considerations will need to be taken into account for the re-use of the existing railway at the decommissioning stage. Should the frequency and severity of flood events increase, the future use of the existing railway as a recreational trail may require improved watercourse crossing structures. This, in the longer term, could also allow for rehabilitation of the creeks and waterways currently affected by the existing railway, as discussed in **Chapter 11, Terrestrial flora** and **Chapter 13, Aquatic biology**.

Residual impact

Extreme climatic events have the potential to have an influence on the environment in the project area during construction or operation of the project. The proposed mitigation measures are considered adequate to reduce the impact of these conditions or events to **negligible** or **minor adverse**.

17.4.3 Sea level rise

Potential impact

Sea level rise as a result of climate change may increase the risk of river flooding in the project area. River flooding can occur when the amount of water exceeds the capacity of the channel; this usually develops during periods of heavy rainfall. This can be exacerbated by tidal flooding caused by storm surges and high tide levels, which may be more likely with climate change and the associated sea level rises. The flood risk for the project and the outcomes of the State Planning Policy Guideline – Mitigating the Adverse Impacts of Flood, Bushfire and Landslide (2003) are discussed in **Chapter 19, Hazard and risk.**

Other impacts include:

- projected rise in sea level, which contributes to the severity of storm surge events

This could lead to increases in inundation as a result of storm surges due to higher mean sea level and more intense weather systems.

- increase risk of flooding (as explained in **Section 17.2.1**).

Mitigation

Mitigation measures are designed to adapt to the effects of Climate Change. This section deals with adaptation as defined in Appendix 3 of the *Guidelines for Preparing a Climate Change Impact Statement* (Office of Climate Change 2008).

- design to avoid high flood risk areas
- earthworks stabilisation measures such as revegetation with appropriate native species
- siting of key infrastructure above flood levels and on structure.

Residual impact

Given the extent of information available currently, it is not possible to provide an assessment of the residual impact significance for sea-level rise.

17.5 Summary and conclusions

Table 17.5: Summary of impacts and mitigation.

Potential Impact	Mitigation Measures	Residual Impacts
Changes in local climate	Monitoring both long and short term weather forecasts Erosion control measures Dust control Changes to work practices if required Health and safety procedures	Negligible
Extreme climate events	Monitoring of forecasts Earthworks stabilisation measures such as revegetation with appropriate native species Implementation of health and safety procedures to reduce the risk of dehydration, heat stroke or sunburn. Disaster and emergency management planning	Minor adverse
Potential increases in sea level affecting project infrastructure	Siting of key infrastructure above flood levels Earthworks stabilisation measures such as revegetation with appropriate native species	Unknown

Local climate, extreme climatic events and climate change have the potential to have an influence on the environment in the project area during construction or operation of the project. Mitigation measures that have been proposed are considered adequate to reduce the impact of these conditions or events to **negligible** or **minor adverse** (see **Section 17.4.2**).